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Three new species of *Diadegma* Förster, 1869 (Hymenoptera, Ichneumonidae, Campopleginae) from the Swiss Alps

Seraina Klopfstein[1,2]

1 *Natural History Museum of Basel, Augustinergasse 2, 4051 Basel, Switzerland*
2 *Institute of Ecology and Evolution, University of Bern, Baltzerstrasse 6, 3012 Bern, Switzerland*

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Corresponding author: Seraina Klopfstein (seraina.klopfstein@bs.ch)

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Abstract

Although Europe is the best-explored continent entomologically, major gaps remain, especially in alpine regions and within taxonomically challenging "dark taxa", such as parasitoid wasps. I describe three new species of Darwin wasps from the Swiss Alps: *Diadegma* (*Nythobia*) *davidmarquesi* **sp. nov.**, *D.* (*Nythobia*) *mirum* **sp. nov.**, and *D.* (*Nythobia*) *orophilum* **sp. nov.** These species were discovered during a revision of Swiss natural history collections and are diagnosed using morphometric characters, microsculpture, and colour patterns, with comparisons to type material. One species appears to have a wider, possibly boreoalpine distribution, whereas the other two are currently known only from montane to alpine habitats in Switzerland. These findings increase the number of *Diadegma* species described from the European Alps to 13 and highlight this region as an important reservoir of undescribed Darwin wasp diversity. They further underscore the need for continued integrative taxonomic work, combining museum revision, targeted alpine sampling, and the collection of host data, to more fully document the hidden diversity and biogeographic importance of Europe's alpine insect fauna.

Key Words

Alpha-taxonomy, alpine endemism, species description

Introduction

Biodiversity is unevenly explored across the globe. Entomologically, Europe is by far the best-documented continent (Rocha-Ortega et al. 2021), but substantial knowledge gaps remain. Long-term, large-scale biodiversity inventories in Sweden have shown that only about 85% of the country's native insect species are currently recorded, with 11% reported for the first time during the past few decades (Ronquist et al. 2020). The faunistic knowledge in Switzerland is likely even less complete, with estimates of the undocumented insect diversity ranging from 27% (Burckhardt 2000) to 43% (Baur and Ungricht 2019). Within Switzerland, alpine regions are expected to harbour a disproportionate share of the missing diversity, both in terms of species not yet recorded for the country and species new to science (e.g., Schwarz 2002; Huemer 2011, 2024; Baur 2015; Aubert et al. 2024; Szallies and Germann 2025).

In addition to geographic biases in our biodiversity knowledge, there are strong taxonomic ones. Large-scale inventories, both morphology- and DNA-based, independently showed that the largest knowledge gaps concern Diptera and Hymenoptera, and in the latter the parasitoid wasps (Hebert et al. 2016; Ronquist et al. 2020). These groups have been termed "dark taxa" and have received renewed attention recently, for instance through the German Barcode of Life project (Haas et al. 2021), although formal taxonomic descriptions in these groups remain patchy and large-scale revisions scarce (but see Klopfstein 2014; Johansson and Cederberg 2019; Johansson 2024; Johansson and Astafurova 2025). The largest family of parasitoid wasps, the Darwin wasps (Ichneumonidae), harbour some of the most understudied groups (Klopfstein et al. 2019). When it comes to alpine species, the genus *Diadegma* Förster, 1869 is a particularly good candidate for exploring the unknown alpine diversity,

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given its considerable size (128 species in Europe: Yu et al. 2016, Shaw et al. 2016) and the fact that there are already ten species described from the Alps, many of which appear to be endemic to that region (Horstmann 1969). Furthermore, the genus parasitizes mostly on several families of Microlepidoptera, such as leaf-mining moths (Gracillariidae), casebearers (Coleophoridae) or snout moths (Pyralidae), which are especially diverse in alpine environments (Huemer 2011; Huemer and Wieser 2023).

Most *Diadegma* species are rather uniform in terms of structural characters and colouration, much more so than the other large genera in the subfamily, *Campoplex* Gravenhorst, 1829, *Dusona* Cameron, 1901, and *Hyposoter* Förster, 1869 (Galsworthy et al. 2023; Horstmann 1985, 2009). The use of morphometric characters in combination with microsculpture nevertheless allows reliable identification of most species. Klaus Horstmann (1969) revised the primary types of the taxa described in this genus and provided an identification key for the 72 species known at the time, although through his focus on type specimens, he neglected the often considerable intraspecific variation. In the following decades, Jacques F. Aubert (1970, 1971, 1974) and especially Horstmann (e.g., 1973, 1980, 2008, 2013) described another 37 European species in the genus. The steady increase in the number of described species in *Diadegma* over this time indicates that there might be more species still awaiting discovery.

During a project that aimed to revise the specimens of Campopleginae in major natural history collections in Switzerland ("SwissCollNet", financed through the Swiss Academy of Natural Sciences ScNat), I identified several hundred specimens of *Diadegma* to species. In the course of this work, I came across three new species, all collected in the Swiss Alps, which I describe below.

Materials and methods

I studied Campopleginae specimens from the collections of the Natural History Museum Basel (**NMB**), the Natural History Museum Bern (**NMBE**), and the Naturéum in Lausanne (**MZL**). Female *Diadegma* specimens were identified using a recently published interactive key (Klopfstein et al. 2022). For species identification, I used a combination of Horstmann's identification key (Horstmann 1969) and comparisons to relevant type material or reference specimens from the collection of Klaus Horstmann, which I obtained on loan from the Zoologische Staatssammlung in Munich (**ZSM**). Taxonomic nomenclature follows Taxapad 2016 (Yu et al. 2016).

Morphological terminology follows Broad et al. (2018). Measurements were taken with an eyepiece with a scale on a Leica MZ12 microscope with 16× oculars. I use measurements and ratios in the diagnoses and descriptions as follows. The ocular-ocellar length (OOL) is measured as the shortest distance between the compound eye and the lateral ocellus, divided by the diameter of the ocellus. The posterior ocellar length (POL) is the shortest distance between the lateral ocelli, divided by the diameter of the lateral ocellus. The dimensions of the face are measured as the shortest distance between the inner margins of the compound eye (usually around the height of the tentorial pits), divided by the distance from a tentorial pit to the ventral rim of an antennal socket. The malar space is measured as the shortest distance between the compound eye and the upper condyle of the mandible, divided by the mandible's height at base, including the basal flange. The length of tergite 1 is measured from the dorsal side of the base to the spot where it meets tergite 2 laterally and is compared to the length of the hind tibia. The length of tergite 2 is measured dorsally along midline and divided by the width at apex. The length of the ovipositor sheath is measured as a straight line from the place it emerges from below the tergites to the tip, ignoring any potential curving.

Photographs were taken with a Keyence VHX-6000 and VHX-X1, using both stacking and stitching techniques at 150–500× magnification. Plates were compiled to illustrate all the relevant characters for species identification.

Results

Among the roughly 1,000 specimens of the genus in the historical material and recent material, I found about 600 females that were identified to species using Horstmann's key (Horstmann 1969), comparisons with more recent descriptions, and most of all, comparisons to type material (males currently cannot be reliably identified). I found three new species in the Swiss Alps, either in the montane, subalpine or alpine zone. For one of the species, I also found a specimen in material from Sweden, while for the other two, the future will have to tell whether they are endemic to the alpine region or also occur elsewhere. The three species are described below. As the only existing key (Horstmann 1969) covers only 72 of the 128 European species, I took special care to provide a detailed diagnosis from all the species with which the new taxa could be confused.

Horstmann (1969, 1987) suggested splitting the European *Diadegma* into four subgenera, *Diadegma* s. str., *Neoangitia* Horstmann, 1969, *Nythobia* Förster, 1869, and *Areolina* Enderlein, 1921. It remains unclear whether they all represent natural groups. However, given that most European species have previously been placed in one of the subgenera, I mention their associations with every first mention of a species below. The new species all belong into the subgenus *Nythobia*, the largest of the four, based on the following combination of characters (Horstmann, 1987): propodeum and metasoma not conspicuously elongate, apical tergites coriaceous, tergite 7 with v-shaped excision, and hind tibia with a rather pronounced banding pattern on the outer side.

Ichneumonidae Latreille, 1802
Campopleginae Förster, 1869
***Diadegma* Förster, 1869**

***Diadegma* (*Nythobia*) *davidmarquesi* sp. nov.**
https://zoobank.org/6E813A00-45EE-4B9F-B9A9-817884D19966
Fig. 1

Etymology. This species is named in honour of David Marques – outstanding naturalist, ornithologist and evolutionary biologist, and most of all esteemed colleague. His dedication to research, to the stewardship of our natural history collections, and to his family have been an inspiration to me ever since we first met. The species epithet is a masculine genitive singular noun.

Material examined. ***Holotype*:** SWITZERLAND • 1♀; Glarus, Linthal, Obersand, Melchplatz; 46.84°N, 8.9306°E; 2051m a.s.l.; 19–28 Jun. 2008; Hannes Baur, Seraina Klopfstein leg.; Malaise trap #3; GBIFCH 02040366 (at NMBE). ***Paratypes*:** • 5♀; [same data as holotype]; GBIFCH 02040367–02040371 (at NMBE) • 5♀; [same data as holotype]; NMB-HYMEN0005555–0005559 (at NMB) • 1♀; [same locality as holotype]; 10–19 Jun. 2008; GBIFCH 02040372 (at NMBE) • 2♀; [same locality as holotype]; 10–19 Jun. 2008; NMB-HYMEN0005560–0005561 (at NMB) • 3♀; Graubünden, Surses, Alp Flix, Clavania; 46.5203°N, 9.6564°E; 1987 m a.s.l.; 20 Jul.–25 Aug. 2008; Hannes Baur, Salome Steiner leg.; Malaise trap #2; GBIFCH 02040373–02040375 (at NMBE) • 4♀; [same data as previous]; NMB-HYMEN0005562–0005565 (at NMB) • 1♀; [same locality as previous]; 23–30 Jun. 2003; Hannes Baur leg.; Malaise trap #1; NMB-HYMEN0005566 (at NMB) • 1♀; [same locality as previous]; 4–20 Jun. 2008; Hannes Baur, Salome Steiner leg.; MalaiseTrap #2; GBIFCH 02040376 (at NMBE) • 1♀; Graubünden, Surses, NE of Sur; 46.5242°N, 9.6342°E; 1770m a.s.l.; 1–25 Sep. 2006; Hannes Baur, Seraina Klopfstein leg.; Malaise trap; NMB-HYMEN0005567 (at NMB) • 1♀; Graubünden, Surses, Alp Flix, Lai Neir; 46.5356°N, 9.6375°E; 1920 m a.s.l.; 15–27 Jul. 2006; Hannes Baur, Seraina Klopfstein leg.; Malaise trap; NMB-HYMEN0005568 (at NMB).

Diagnosis. *Diadegma davidmarquesi* has a characteristic, small and posteriorly converging area superomedia, but this character can be difficult to judge without having a lot of comparative material at hand. The new species also has a strong dark mark at the base of the hind femur, which further strengthens the impression of a dark-and-light banded leg caused by the ivory hind tibia with the strong subbasal and apical bands. Such a strong darkening of the base of the hind femur otherwise only occurs in *D.* (*Nythobia*) *fenestrale* (Holmgren, 1860), from which the new species can be distinguished from by the shorter ovipositor (0.6–0.75 versus 0.95–1.05 in *D. fenestrale*), the smaller and posteriorly converging area superomedia, and the generally lower OOL (0.85–1.05 versus 1.0–1.35). *Diadegma* (*Nythobia*) *semiclausum* (Hellén, 1949) also often has a dark marking below on the hind femur, although it is usually rather weak. The new species can be distinguished from *D. semiclausum* by the dark front coxa (at most with base a bit darkened in the latter), dark scape (nearly always marked with yellow below), and the higher OOL (1.45 –1.80 versus 1.15–1.45). Furthermore, *D. davidmarquesi* generally has longer antennae (24–26 flagellomeres versus nearly always 23, very rarely 24) and a longer tergite 2 (1.3–2.1 times longer than wide, versus 1.15–1.35).

In Horstmann's key (Horstmann 1969), this species runs to group III (species with deeply excised tergite 7 and ovipositor sheath shorter than hind tibia), and within the group to *D. semiclausum* (under the junior synonym *D. eucerophagum* Horstmann, 1969); see above for distinguishing features from that species. Among the group III species described after 1969, only two are similar to *D. davidmarques* in having the hind tibia ivory medially and tergite 6 not or weakly excised: *Diadegma* (*Nythobia*) *hispanicum* Horstmann, 1973 and *D.* (*Nythobia*) *incompletum* Horstmann, 1973, but both never have the fore coxa dark, never have a dark mark basoventrally on the hind femur, and the latter furthermore has the longitudinal carinae on the propodeum strongly reduced.

Description. Body 5.2–6.1 (5.9) mm. Temple in lateral view 0.70–0.95 (0.85) times as long as eye, dorsally rather steeply, at mid-height of eye evenly and roundly constricted; OOL 0.85–1.05 (1.0), POL 1.4–1.8 (1.4); face 1.30–1.40 (1.35) times as wide as high, with strong coriaceous microsculpture against which punctures are disappearing, matt; malar space 0.70–0.90 (0.85) times width of mandible at base; clypeus a little rounded in profile, with weak microsculpture against which some punctures are visible; apical margin of clypeus somewhat impressed and reflexed as a weak lamella, especially laterally, margin slightly convex in frontal view. Antenna with 24–26 (26) flagellomeres, all of which longer than wide, tapering towards apex.

Pronotum coriaceous above, in lower half with longitudinal rugae, not bulging below mesoscutum, epomia short; mesoscutum coriaceous, at most with indistinct punctures on lateral parts; scuto-scutellar groove smooth; mesopleuron strongly coriaceous, with a few weak punctures indicated ventrally and anteriorly, smooth around speculum, anterior to it with longitudinal rugulae; metapleuron coriaceous and slightly shiny above.

Fore wing 3.6–4.4 (4.1) mm, areolet quadrate, small to medium-sized, weakly to strongly petiolate above, with vein 2m-cu meeting it clearly apically of middle. Hindwing with nervellus nearly vertical, weakly rounded, unbroken. Hind femur 4.6–5.2 (4.9) times as long as high; hind claw not much surpassing pulvillus in lateral view, with strong pecten reaching to more than half its length, nearly as long as claw itself.

Propodeum with carinae strong, coriaceous in area basalis, area externa and area superomedia, with rugae in area dentipara and strong, transverse rugae in area petiolaris; area basalis short, triangular, directly meeting area super-

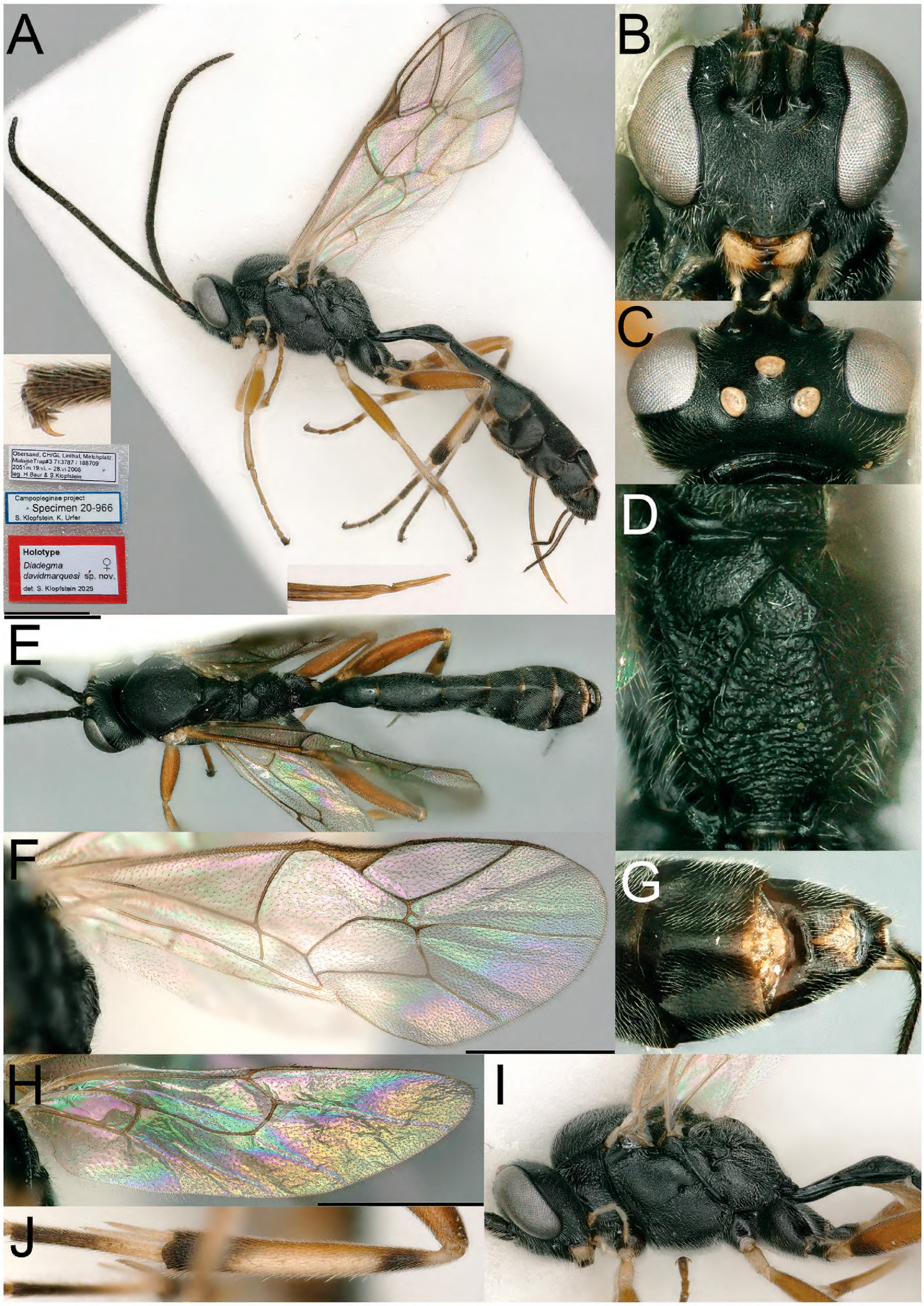

Figure 1. *Diadegma davidmarquesi* sp. nov. holotype female, GBIFCH 02040366. **A.** Habitus in lateral view, with inlays showing the hind claw, ovipositor tip and original labels; **B.** Head in frontal view; **C.** Head in dorsal view (here of specimen NMB-HY-MEN0005566, as view was obstructed in holotype); **D.** Propodeum in dorsal view; **E.** Habitus in dorsal view; **F.** Fore wing; **G.** Last tergites showing median excisions; **H.** Hind wing; **I.** Lateral view of head, mesosoma and first tergite; **J.** Hind tibia. ©S. Klopfstein, Natural History Museum Basel.Scale bars: 1 mm (**A, E, F, H**).

omedial; area superomedia rather small, pentagonal with lateral sides clearly converging, shorter than to nearly as long as wide, posteriorly open to nearly closed by a transverse ruga; area petiolaris somewhat impressed medially.

Metasoma laterally compressed, widest around tergite 4 or 5, coriaceous sculpture becoming weaker towards apex where it ends up rather shagreened and with minute punctures around hair roots. Tergite 1 0.6–0.7 (0.6) times as long as hind tibia, with small, deep glymma at about halfway between base and spiracle, postpetiolus first rounded, then nearly flat dorsally. Tergite 2 1.30–2.10 (1.65) times longer than wide at apex, tergite 6 not or very weakly excised, tergite 7 deeply excised. Ovipositor sheath 0.60–0.75 (0.65) times as long as hind tibia, evenly upcurved, rather thin, with notch rather distant from apex, ventral valves with minute teeth.

Black; palps, mandibles except teeth, tegula, wing base, and all trochantelli light yellow; scape black; wing venation brown, pterostigma medium brown. All coxae black, fore and mid trochanters orange at base, remainder light yellow, hind trochanter black with yellow apex, all femora orange, hind femur with large black mark at base, especially ventrally, and often dorsally at apex; fore and mid tibiae orange, often ivory on outer side, mid tibia with indication of subbasal and apical brown bands, tarsi orange to brown; hind tibia on the inner side orange, on the outer ivory at base and medially, dark brown to black subbasally and apically; hind spurs and base of first tarsomere ivory, remainder dark brown. Metasoma entirely dark.

No host data is available to date for this species.

Diadegma (*Nythobia*) *mirum* sp. nov.

https://zoobank.org/7A5E6167-0B84-438B-80D9-1D05D6B9FA5C

Fig. 2

Etymology. The species epithet is derived from the Latin word mīrum, meaning "wonderful" – which all of Earth's creatures ultimately are. The species epithet is an adjective in neuter nominative singular form, as the genus name *Diadegma* is neuter.

Material examined. ***Holotype*:** Switzerland • 1♀; Bern, Saanen, Krinnen; 13–14 Sep. 1969; Jacques Aubert leg.; GBIFCH 02040377 (at MZL). ***Paratype*:** Sweden • 1♀; Kalmar län, Öland, Borgholm, Alvara Dödevi; 57.1872°N, 17.068°E; 12 Jul. 2022; Seraina Klopfstein leg.; NMB-HYMEN0005569 (at NMB).

Diagnosis. The new species is one of just five species in the genus in Europe that have the punctation on the lower mesopleuron stronger than the coriaceous background. *Diadegma* (*Nythobia*) *integrator* Aubert, 1970 and *D.* (*Nythobia*) *rectificator* Aubert, 1970 both have tergites 6 and 7 not or weakly excised, while *D.* (*Neoangitia*) *aculeatum* (Bridgman, 1889) has an ovipositor that is much longer than the hind tibia and shiny posterior tergites. The most similar species in Europe with rather strong punctation on the mesopleuron is *D.* (*Nythobia*) *areolare* (Holmgren, 1860), a species known to me only from a single specimen in the Thomson collection in Lund (marked by Jacques F. Aubert as "TYPE!?"). The new species can be distinguished from it by its medially orange hind tibia (ivory in *D. areolare*), the areolet being met by vein 2m-cu a little apically of its middle (clearly basally in *D. areolare*), and by the much shorter area superomedia (which is nearly twice longer than wide in *D. areolare*).

In Horstmann's key (Horstmann 1969), this species runs to group III (species with deeply excised tergite 7 and ovipositor sheath shorter than hind tibia), and within the group to either *D.* (*Nythobia*) *areolare*, *D.* (*Nythobia*) *tenuipes* (Thomson, 1887), or *D.* (*Nythobia*) *combinatum* (Holmgren, 1860). While the first of these species is already excluded above, the remaining two have the punctures on the mesopleuron at most as conspicuous as the background sculpture. From *D. tenuipes*, *D. mirum* can be further distinguished by its dark fore coxa and trochanter (orange and yellow, respectively, in *D. tenuipes*) and the higher POL (1.80–1.95 versus 1.25–1.45 in *D. tenuipes*). The new species shares both these characters with *D. combinatum* but has its inner eye margins almost parallel ventrally (strongly converging in *D. combinatum*), a lower OOL (1.05–1.10 versus 1.35–1.50 in *D. combinatum*), and its ovipositor evenly upcurved (nearly straight in *D. combinatum*).

Among the group III species described since 1969, none has a medially orange hind tibia combined with an at least somewhat excised tergite 6 and dark-marked fore trochanters. However, *D.* (*Nythobia*) *alpinator* Aubert, 1970 meets all these criteria and was not included in the 1969 key. It was originally described as a subspecies of *D. combinatum* (Aubert 1970), later synonymized with that taxon by Horstmann (1973), and only thirty year later resurrected as a separate species (Horstmann 2013). The new species can be distinguished from *D. alpinator* by the more deeply excised tergite 6, the longer tergite 2 (1.40 versus 1.05–1.15 in *D. alpinator*), the more distinctly banded hind tibia, and the lower OOL (1.05–1.10 versus 1.25–1.40 in *D. alpinator*).

Description. Measurements are based on the two females in the type series, with the value of the holotype repeated in brackets.

Body 5.1–6.3 (6.3) mm. Temple in lateral view 0.75 times as long as eye, strongly and roundly constricted; OOL 1.05–1.10 (1.05), POL 1.80–1.95 (1.95); face 1.25–1.30 (1.25) times as wide as high, with coriaceous microsculpture and distinct punctures, especially in lower part, matt; malar space 0.5–0.7 (0.7) times width of mandible at base; clypeus a little rounded in profile, with weak microsculpture and distinct punctures; apical margin of clypeus somewhat impressed and reflexed as a weak lamella, margin convex in frontal view. Antenna with 26–28 (28) flagellomeres, about as long as wide or slightly longer in apical third, tapering towards apex.

Pronotum above punctate on nearly smooth background, in lower half with longitudinal rugae, not bulging below mesoscutum, epomia rather long; mesoscutum coriaceous, with distinct punctures on entire surface; scu-

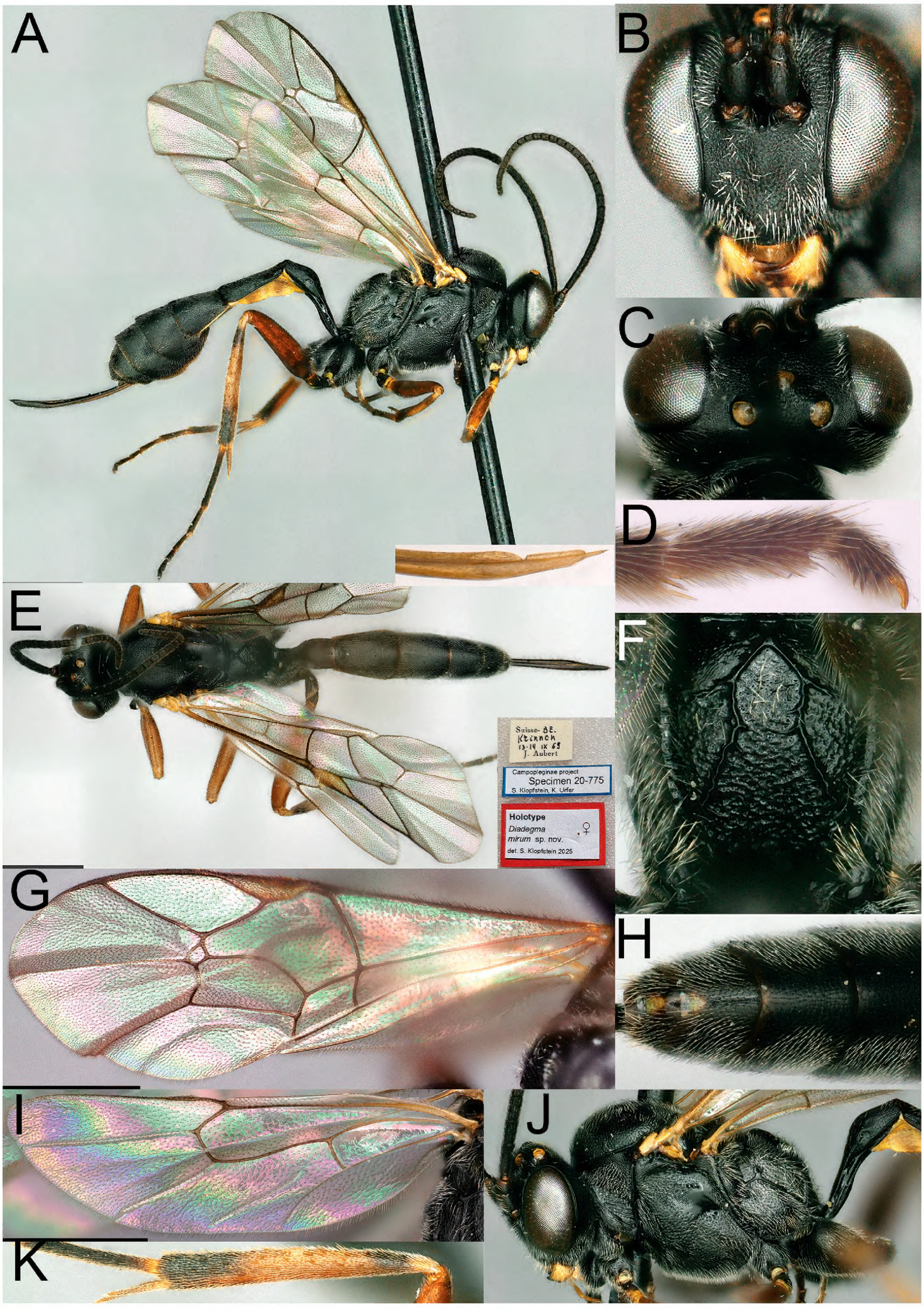

Figure 2. *Diadegma mirum* sp. nov. holotype female, GBIFCH 02040377. **A.** Habitus in lateral view, with inlay showing ovipositor tip; **B.** Head in frontal view; **C.** Head in dorsal view; **D.** Hind claw. **E.** Habitus in dorsal view, with inlay showing labels; **F.** Propodeum in dorsal view; **G.** Fore wing; **H.** Last tergites showing median excisions; **I.** Hind wing; **J.** Lateral view of head, mesosoma and first tergite; **K.** Hind tibia. ©S. Klopfstein, Natural History Museum Basel. Scale bars: 1 mm (**A, E, G, I**).

to-scutellar groove smooth; mesopleuron only weakly coriaceous, nearly smooth in most parts, with strong and dense punctures, smooth around speculum, anterior to it with longitudinal rugulae amidst the punctation; metapleuron largely smooth and with strong punctures.

Fore wing 3.25–4.60 (4.60) mm, areolet quadrate, medium-sized to large, strongly petiolate above, with vein 2m-cu meeting it a bit apically of its middle. Hindwing with nervellus nearly vertical, weakly rounded, unbroken. Hind femur 4.75–4.80 (4.80) times as long as high; hind claw not surpassing pulvillus in lateral view, with strong pecten reaching to more than half its length, a bit shorter than claw itself.

Propodeum with carinae strong, coriaceous in area basalis and area externa, rugulose in area dentipara and area superomedia, with transverse rugae in area petiolaris; area basalis short, triangular, directly meeting area superomedia; area superomedia of average size, long pentagonal with lateral sides slightly converging, a bit longer than wide, posteriorly open; area petiolaris very weakly impressed medially.

Metasoma laterally compressed, widest around tergite 2 or 3, coriaceous and with weak but dense punctures. Tergite 1 with small, deep glymma a bit closer to spiracle than to base, postpetiolus first rounded, then flat dorsally. Tergite 2 1.40–1.45 (1.40) times longer than wide at apex, tergites 6 and 7 deeply excised. Ovipositor sheath 0.85–0.90 (0.90) times as long as hind tibia, evenly upcurved, with notch rather distant from apex, ventral valve apparently smooth.

Black; palps, mandibles except teeth, tegula, wing base, and fore trochantellus yellow; scape black; wing venation brown, pterostigma medium brown. All coxae black; trochanters and mid and hind trochantelli black at base, narrowly yellow at apex; femora light to dark orange, ventrally marked with black at least at base; fore and mid tibiae orange, mid tibia with indication of subbasal and apical brown marks, tarsi orange to brown; hind tibia on the inner side orange, on the outer ivory at base, orange medially, dark brown to black subbasally and apically; hind spurs and base of first tarsomere orange to brown, remainder dark brown. Metasoma entirely black.

No host data is available for this species.

Diadegma (*Nythobia*) *orophilum* sp. nov.

https://zoobank.org/C44FC9EB-ED6B-47B7-B27A-22CF962ACF52

Fig. 3

Etymology. The species epithet is derived from the Greek words oro- (ὄρος) for mountain and -philum (φίλος) for loving – the mountain-loving wasp. The species epithet is an adjective in neuter nominative singular form, as the genus name *Diadegma* is neuter.

Material examined. ***Holotype*:** Switzerland • 1♀; Graubünden, Ilanz-Riein, Piz Riein; 2600 m a.s.l.; Aug. 2014; Jürg Schmid leg.; reared from *Plutella geniatella* Zeller, 1839; NMB-HYMEN0005570 (at NMB). ***Paratype*:** Switzerland • 1♂; Graubünden, Bergün, Albulapass; 2300 m a.s.l.; 24 Mar. 2013; Jürg Schmid leg.; reared from *Plutella geniatella*; NMB-HYMEN0005571 (at NMB).

Diagnosis. The combination of a black hind femur and deeply excised tergites 6 and 7 is only shared by two other alpine species, *D. alpinator* and *D.* (*Nythobia*) *ericinellae* Horstmann, 2013. From both, it can be distinguished by the lower POL (~1.30 in the new versus 1.65–2.10 in the other two species) and the longer ovipositor (~1.05 versus 0.65–0.90). From *D. alpinator*, it can further be told apart by the hind tibia being ivory medially (versus orange brown in *D. alpinator*), the longer tergite 2 (1.60 versus 1.05–1.15), the more deeply excised tergite 6, and the lower OOL (~0.95 versus 1.25–1.40). From *D. ericinellae*, the new species differs also by the larger malar space (0.75 times as long as mandible at base, versus 0.50–0.55 in *D. ericinellae*).

In Horstmann's key (Horstmann 1969), *D. orophilum* runs to group IV (species with deeply excised tergite 7 and ovipositor sheath longer than hind tibia), and within the group to *D. fenestrale*. Besides the darker femora and trochanters, it can be distinguished from that species by the longer tergite 2 (~1.60 versus 1.20 –1.45 in *D. fenestrale*), the lower OOL (~0.95 versus 1.00–1.40) and POL (~1.35 versus 1.60–2.00), the narrower clypeus, which is somewhat convex in cross-section, and the smaller and posteriorly converging area superomedia. *Diadegma fenestrale* has a large dark mark at the base and ventrally on the hind femur, but that mark never extends over the entire femur.

Among the group IV species described after 1969, four species have the hind tibia ivory or light yellow medially, tergite 6 deeply excised and sometimes dark for coxae. Besides its mainly dark hind femur, the new species differs from these by the following characters: from *D.* (*Neoangitia*) *albotibiale* Horstmann, 1973 by the somewhat coriaceous microsculpture of the last tergites (nearly smooth and strongly shiny in *D. albotibiale*) and tergite 7 with excision v-shaped (wide and parallel-sided in *D. albotibiale*); from *D.* (*Nythobia*) *nigridens* Horstmann, 2008 by the yellow mandibles (conspicuously darkened in *D. nigridens*) and more narrow face (~1.25 versus 1.50–1.60 in *D. nigridens*); from *D.* (*Nythobia*) *suecicum* by the dark metasoma (with extensive orange markings laterally on most tergites in *D. suecicum*) and the shorter antennae (24–28 versus ~37 flagellomeres in *D. suecicum*); and from *D.* (*Areolina*) *valesiator* Aubert, 1970 by the metasoma shape (very strongly laterally compressed, almost knife-like in *D. valesiator*) and the shorter propodeum (elongate between hind coxae in *D. valesiator*).

Description. As only one female and one male are available of this species, I give measurements of both sexes here, with the measurement of the female holotype repeated in the brackets.

Body 5.3–5.8 (5.3) mm. Temple in lateral view 0.65–0.80 (0.65) times as long as eye, rather steeply and strongly constricted behind the eyes; OOL 0.90–1.0 (1.0), POL 1.30–1.35 (1.35); face 1.2 times as wide as high, with strong coriaceous microsculpture against which

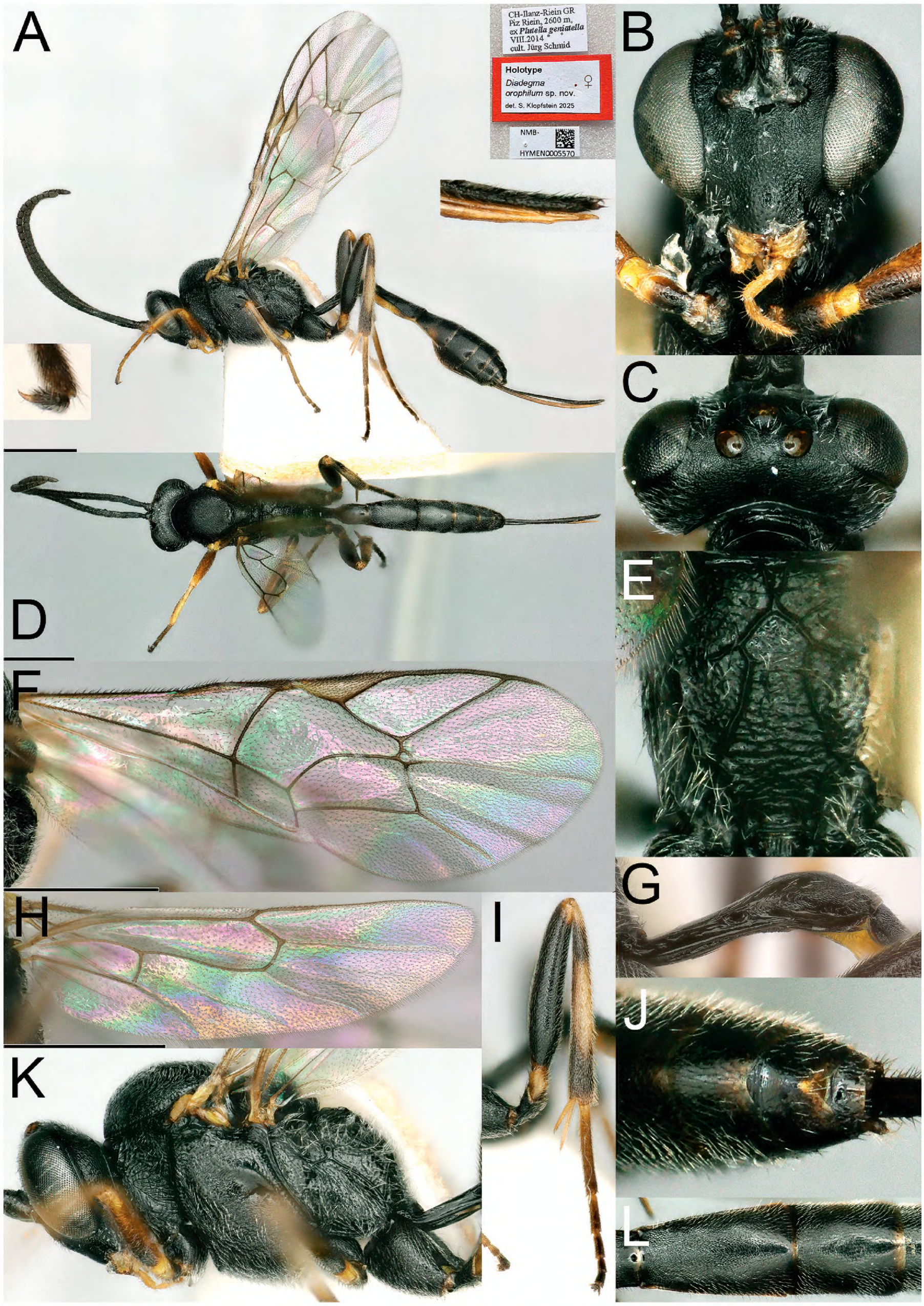

Figure 3. *Diadegma orophilum* sp. nov. holotype female, NMB-HYMEN0005570. **A.** Habitus in lateral view, with inlays showing the hind claw, original labels and ovipositor tip; **B.** Head in frontal view; **C.** Head in dorsal view; **D.** Habitus in dorsal view; **E.** Propodeum in dorsal view; **F.** Fore wing; **G.** First metasomal segment in lateral view. **H.** Hind wing; **I.** Hind tibia; **J.** Last tergites showing median excisions; **K.** Lateral view of head and mesosoma; **L.** Second and third tergites in dorsal view. ©S. Klopfstein, Natural History Museum Basel. Scale bars: 1 mm (**A, D, F, H**).

punctures are disappearing; malar space 0.75 times width of mandible at base; clypeus a little rounded in profile, clearly rounded in cross-section, rather weekly coriaceous and clearly punctured; apical margin of clypeus rather flat, convex in frontal view. Antenna with 24–28 (24) flagellomeres, weakly tapering towards apex, around last third with segments about as long as wide.

Pronotum irregularly rugulose above, in lower half with longitudinal rugae, not bulging below mesoscutum, epomia short; mesoscutum coriaceous, at most with indistinct punctures on lateral parts; scuto-scutellar groove smooth; mesopleuron strongly coriaceous and with indistinct punctures in lower half, more shiny and rugulose with clear punctures in upper half, smooth around speculum, anterior to it with longitudinal rugulae; metapleuron rugulose and shiny with punctures indicated.

Fore wing 4.05–4.20 (4.05) mm, areolet quadrate, medium-sized to large, weakly to strongly petiolate above, with vein 2m-cu meeting it around its middle. Hindwing with nervellus nearly vertical, weakly rounded, unbroken. Hind femur 5.0–5.5 times as long as high; hind claw not much surpassing pulvillus in lateral view, with pecten reaching to about half its length, clearly shorter than claw itself.

Propodeum with carinae strong, rugulose all over and with strong, transverse rugae in area petiolaris; area basalis short, triangular, meeting area superomedial in a short stalk; area superomedia rather small, pentagonal with lateral sides clearly converging, shorter than wide, posteriorly open; area petiolaris barely impressed medially.

Metasoma laterally compressed, widest around tergite 3, coriaceous sculpture becoming weaker towards apex where it ends up rather shagreened and with minute punctures around hair roots. Tergite 1 0.6 times as long as hind tibia, with small, deep glymma a little closer to spiracle than to base, postpetiolus first rounded, then flat to a little concave dorsally. Tergite 2 1.55–1.65 (1.55) times longer than wide at apex, tergite 6 with deep but u-shaped, tergite 7 with deep, v-shaped excision. Ovipositor sheath 1.0 times as long as hind tibia, evenly upcurved, rather thin, with notch rather distant from apex, ventral valves apparently smooth.

Black; palps, mandibles except teeth, tegula, wing base, and all trochantelli yellow, hind trochantellus with base black; scape black; wing venation dark brown, pterostigma medium brown. All coxae black, trochanters black with a narrow yellow apex; fore and mid femora orange, blackened ventrally and basally, hind femur black with a narrow orange apex; fore and mid tibiae orange, ivory on outer side, mid tibia with indication of subbasal and apical brown marks, tarsi orange to brown; hind tibia on the inner side brownish orange, on the outer ivory at base and medially, dark brown to black subbasally and apically; hind spurs and base of first tarsomere ivory, apex of spurs and remaining tarsomeres dark brown. Metasoma black, in both sexes with weak orange mark laterally on tergite 3.

Both specimens in the type series have been reared from *Plutella geniatella* (Lepidoptera, Plutellidae), a species occurring exclusively at high altitudes (Baraniak 2007).

Discussion

The three new species described here from the Swiss Alps highlight the still partially unexplored diversity of alpine regions, which is likely to be revealed through more extensive sampling, particularly when "dark taxa" like Darwin wasps are prioritized. Similar discoveries have been made steadily over the past decades. In a study of Darwin wasps above the tree line in Hohe Tauern (Austria), Schwarz (2002) found many rare or even undescribed species and estimated that about 10% of the ichneumonid species found in the Alps will ultimately prove to be new to science. Likewise, during a revision of the comparatively well-studied subfamily Diplazontinae in the Western Palaearctic, Klopfstein and co-authors (Klopfstein et al. 2007; Klopfstein 2014) described seven new species, three of which were discovered in the Alps. In addition, Jacques F. Aubert described nearly 40 new species from various subfamilies from the Col de Bretolet in Valais, at approximately 2,000 m a.s.l. (e.g. *Erromenus alpestrator* Aubert, 1969, *E. alpinator* Aubert, 1969, *Scambus alpestrator* Aubert, 1966, *Theroscopus alpator* Aubert, 1989: Aubert 1966; 1969; 1989).

In *Diadegma*, the present contribution increases the number of species described from the European Alps to 13, seven of which seem to be restricted to that region, including – at least for now – *D. davidmarquesi* and *D. orophilum*. While the former was found in the montane and subalpine zones (1,770–2,051 m), the latter was collected through its host from the alpine zone (2,300–2,600 m; Baraniak 2007). The future will tell whether these two species are indeed endemics of the Alps or if they have a larger distribution range. The third species, *D. mirum*, was found both on a mountain pass in Switzerland, at 1,660 m, and on the island Öland in Sweden, around 20 m above sea level, suggesting that it might either have a boreoalpine or an even wider distribution.

It was clear from Horstmann's string of new species descriptions in this genus over the years, which only ended with his death, that there are additional new *Diadegma* species to be discovered in Europe. The small number of specimens of the three new species I describe here further supports this notion. For both *D. mirum* and *D. orophilum*, I only had two specimens each to base my descriptions on. And while the number of specimens was much larger for *D. davidmarquesi* (25 specimens), these were collected only in two localities, on Melchplatz in Obersand in the canton Glarus and on Alp Flix in the Grissons. Increased sampling effort, both in the Alps and in Europe in general, will thus certainly reveal additional new species.

The large proportion of alpine species (13 out of 128 = 10%) is somewhat in contrast to the results of a recent study that examined altitudinal diversity patterns in Switzerland in the closely related genus *Hyposoter* (Meier et al. 2026). In that study, only three out of 71 European species (4%) had their median recorded elevation above 1,500 m. Furthermore, while all *Diadegma* species described from the Alps show conspicuous darkening in comparison to low-altitude species, especially of the legs, no such differ-

ences were found in *Hyposoter*. As that study was based on the same natural history collections as the current one, sampling biases can be excluded as an explanation here. More likely, the different host ranges are the reason for this difference in altitudinal distribution patterns in these two closely related genera. While a formal analysis of the diversity patterns in their hosts would be beyond the scope of the current study, it should be noted that in contrast to *Hyposoter*, which parasitizes exposed caterpillars, *Diadegma* specializes on attacking concealed hosts (Shaw et al. 2016). These either live hidden in plant tissue, for instance as leaf-miners (Gracillariidae, Plutellidae, Lyonetiidae etc.) or plant-borers (Pyralidae, Gelechiidae etc.), or they build their own shelter that they carry around with them, as case-builders (Coleophoridae, Psychidae etc.). It is conceivable that caterpillars living at higher altitude might profit from such partially hidden lifestyles. Indeed, some of the moth families that are known as popular hosts of *Diadegma* are particularly diverse in the Alps (Pinkert et al. 2025), above all the casebearers (Coleophoridae), which have an especially high proportion of alpine endemics (Huemer 2011; Schmid 2017).

I here could only report host data for one of the three species described, *D. orophilum*, which was reared from the plutellid *Plutella geniatella*, an alpine endemic (Baraniak 2007). It remains to be shown whether the new *Diadegma* species is a specialist on this one host species, or whether it attacks other microlepidopterans. Among the species of the genus, a wide range of levels of specialization have been reported, with some species found to date only on a single host species or at least family, while others seem able to cope with the defences of the larvae of several lepidopteran families (Shaw et al. 2016). Being able to report a host record at the same time as describing a new parasitoid species is of course highly desirable, as it immediately creates links to both ecology and co-evolution. However, I decided to also describe the other two new species, as having described them might spur further effort into elucidating their host relationships and – given the current difficulties in species identification in the genus – might help avoid host records being attributed to the wrong, previously named species (Shaw 2023).

Eventually, molecular data, will be needed to assess the current circumscription of *Diadegma* and to test the monophyly of its subgenera (Horstmann 1987). At the species level, the use of standard markers like the barcoding region of CO1 and ITS2 will not only strengthen species hypotheses, but also facilitate reliable identification of the species by non-specialists, as these wasps regularly appear in ecological and biocontrol projects (Furlong et al. 2013; Yoshimura et al. 2023).

Conclusions

The three new *Diadegma* species described here further demonstrate the importance of alpine regions for the discovery of previously unknown insect species in Europe. My results emphasize the Alps as a hotspot of overlooked diversity, especially within taxonomically challenging groups such as Campopleginae. The comparatively high proportion of alpine *Diadegma* species, compared to related genera, likely reflects differences in host ecology, particularly the use of concealed microlepidopteran hosts at higher elevations. Continued taxonomic revision – ideally integrating molecular data, targeted alpine sampling, and increased efforts at host rearing will be essential to better document the diversity and ecological roles of these dark taxa.

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Supplementary material 1

Specimen Data in Darwin Core Format

Author: Seraina Klopfstein
Data type: xlsx
Explanation note: Complete specimen data organized in Darwin Core fields of all the type material of the three new species.
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Link: https://doi.org/10.3897/alpento.10.184715.suppl1